

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



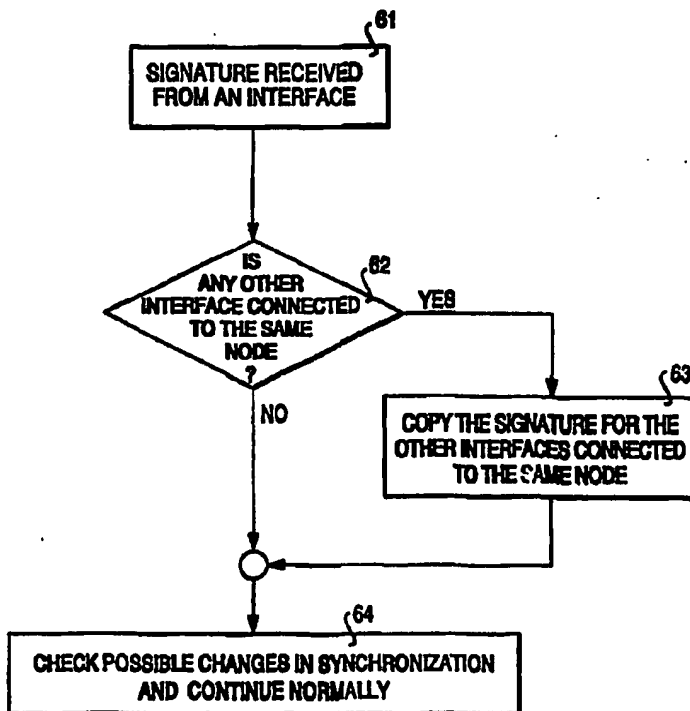
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification ⁶ : H04Q</p>	<p>A2</p>	<p>(11) International Publication Number: WO 95/24801</p> <p>(43) International Publication Date: 14 September 1995 (14.09.95)</p>
<p>(21) International Application Number: PCT/FI95/00113</p> <p>(22) International Filing Date: 28 February 1995 (28.02.95)</p> <p>(30) Priority Data: 940980 1 March 1994 (01.03.94) FI</p> <p>(71) Applicant (for all designated States except US): NOKIA TELECOMMUNICATIONS OY [FI/FI]; Mäkkylän puistotie 1, FIN-02600 Espoo (FI).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): KAINULAINEN, Jukka [FI/FI]; Ratavallintie 26 H 60, FIN-00720 Helsinki (FI).</p> <p>(74) Agent: OY KOLSTER AB; Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).</p>		<p>(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).</p> <p>Published <i>In English translation (filed in Finnish). Without international search report and to be republished upon receipt of that report.</i></p>

(54) Title: HIERARCHICAL SYNCHRONIZATION METHOD

(57) Abstract

The invention relates to a hierarchical synchronization method for a telecommunications system employing message-based synchronization and comprising a plurality of nodes interconnected by transmission lines (A, B). In the method the nodes interchange signals comprising synchronization messages with a synchronization signature indicating the priority of the corresponding signal in the internal synchronization hierarchy of the system. There are several transmission lines between two nodes, and the same synchronization signature is transmitted over more than one of these transmission lines. In order to enable as fast resynchronization as possible, the node operates in such a way that when the synchronization signature received from a neighbouring node connected to several node interfaces changes, the node copies the new signature of the interface which received the changed signature to immediately apply also to the other interfaces connected to the same neighbouring node and used for synchronization.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

Hierarchical synchronization method

5 The invention relates to a hierarchical
synchronization method according to the preamble of the
appended claim 1, the method being used in a
telecommunications system employing message-based
10 synchronization. The invention also relates to a node
equipment according to the preamble of the appended
claim 7, realizing such a method.

 In this presentation, the junction points of
the transmission lines in a system are called nodes. A
node may be any device or equipment capable of affecting
15 clock synchronization, such as a branching or cross-
connection means.

 Nodes in a system utilizing message-based
synchronization are interconnected by transmission lines
which the nodes use for data transmission. These lines
20 also forward the clock frequency of the transmitting
party to the receiving party. Each node selects as the
source of its own clock frequency either the frequency
of a signal from a neighbouring node, the frequency of
its own internal clock source, or a frequency brought
25 into the node from an external clock source through a
separate synchronization input. In order that all nodes
in the system would operate at the same clock frequency,
the aim is usually to make the system synchronize itself
with a single clock source called a master source. All
30 system nodes connected directly to the selected master
source are thus synchronized with the master source
while nodes connected to the nodes adjacent to the
master source but not directly connected to the master
source are synchronized with these adjacent nodes.
35 Accordingly, each node at a greater distance from the

master source synchronizes itself with a node one node spacing closer to the master source.

In order that the above-described synchronization hierarchy could be established within the system, the system nodes interchange synchronization messages. These messages contain information by means of which individual nodes are able to select a timing source. The system nodes are prioritized and the system tends to synchronize itself with the clock frequency of a node having the highest level of priority. Normally each priority level is assigned to a single system node. Synchronization messages normally contain information about the origin of the clock frequency of the node transmitting the message and the priority of the node as well as a value describing the quality of the clock signal. Accordingly, a neighbouring clock frequency which originates from a desired node and which is of the highest quality can be selected by an individual node as the source of its own clock frequency. At the system start-up each node selects its own internal clock source as the source of its clock frequency as it has not yet processed any incoming synchronization messages. After the node has processed the first incoming synchronization messages, it selects the clock frequency of a neighbouring node having the highest level of priority as the source of its clock frequency. After all messages have been distributed over the system and the system has achieved a stable state as far as synchronization is concerned, the system has been synchronized hierarchically with the clock frequency of the master source.

Figure 1 shows a system utilizing message-based synchronization in a stabilized situation. Priorities assigned to the nodes are indicated by numbers within the circles representing the nodes. The smaller the

number, the higher the priority of the node. Synchronization messages transmitted by a node n ($n=1\dots6$) are indicated by the reference MSG_n . Synchronization messages transmitted by different nodes usually differ from each other and depend on the applied message-based synchronization method. The distribution of the clock frequency from the master clock (node 1) to the other system nodes is illustrated by solid lines. Internodal connections drawn by broken lines are not used in a normal situation for system synchronization, but they are available in change situations.

Message-based synchronization is based on a simple principle that the user defines the synchronization hierarchy of the system nodes by assigning each node a dedicated signature indicating the hierarchical level of the node and the system synchronizes itself with the defined master clock independently by utilizing, if required, all existing internodal connections. If the connection to the master clock breaks, and no alternative connection exists, or if the master clock fails, the system synchronizes itself with a node of the next highest level of hierarchy. Response to the change in synchronization takes place by message interchange between nodes.

A message-based synchronization method of the type disclosed above is described e.g. in US Patent 2,986,723, which is referred to for a more detailed description. Messages used in this type of known message-based synchronization method (SOMS) are described in greater detail below in connection with Figures 2 and 3, since the method according to the present invention is applicable for example in this type of system.

When a node in a system employing message-based synchronization changes its outgoing message, it is

usually changed in all transmission lines. The neighbouring node must normally process separately the synchronization signatures contained in the messages arriving at the interfaces. In a node connected to its
5 neighbouring node by means of more than one transmission line, the synchronization with the right source may thus be slower in situations where one of the lines to the neighbouring node has been selected as the source of synchronization. When the synchronization signature
10 transmitted by the neighbouring node deteriorates, it is possible that the node synchronization decision means first receives the deteriorated signature of the selected interface, whereupon the interface goes down on the priority list and the top of the list will most
15 likely be occupied by another interface connected to the same neighbouring node. After a while the decision means receives the new signature arriving at the latter interface, whereupon the interface goes down on the priority list. Even though this process is performed
20 rapidly on all interfaces down to the last interface connected to the same neighbouring node, it causes unnecessary changes and intermediate states on the priority list and slows down the synchronization of the node with the right source. A similar problem also
25 occurs if the decision means first receives the changed signatures of the other interfaces, and the signature of the selected source is "overrun" and arrives only after the other signatures. The most significant information (a change in the signature of the interface
30 selected as the synchronization source) is then received last, whereupon the decision-making has been unnecessarily delayed.

The purpose of the present invention is to
eliminate the aforementioned drawbacks and to provide
35 a method which ensures as fast resynchronization as

possible in a node connected to a neighbouring node by means of several transmission lines. This aim is achieved with the method according to the invention, the first embodiment of the method being characterized by what is described in the characterizing portion of the appended claim 1, and the second embodiment being characterized by what is described in the characterizing portion of the appended claim 5. The node equipment according to the invention is in turn characterized by what is described in the characterizing portion of the appended claim 7.

The central idea of the invention is to copy the changed synchronization signature received first from the neighbouring node to immediately apply also to the other interfaces connected to the node and used for synchronization. In the most preferred embodiment of the invention the synchronization signature is copied for the other interfaces only if it has deteriorated. An improved signature may also be copied, even though this does not actually increase the performance. (A deteriorated signature means that the signature has a lower priority level than before.)

The arrangement according to the invention can be used in message-based synchronization methods where (a) a node transmits the same synchronization signature to all directions, or (b) the same signature is transmitted over each connection between two nodes, or (c) the system knows otherwise those connections between two nodes over which the same synchronization signature is transmitted. This information may be incorporated into the system already at the system set-up, or the user may define these connections.

By means of the solution according to the invention, the information central to the synchronization can be provided to the node

(synchronization) decision means faster than before, unnecessary intermediate states can be avoided in change situations, and a correct decision can be made more rapidly than in known solutions.

5 In the following, the invention and its preferred embodiments will be described in greater detail with reference to the examples according to Figures 2 to 9 in the accompanying drawings, in which

10 Figure 1 shows a system employing message-based synchronization when the system is in synchronization with the clock frequency of a master source,

 Figure 2 shows a network employing self-organizing master-slave synchronization (SOMS) in an initial state,

15 Figure 3 shows the network of Figure 2 in a stable state,

 Figure 4 illustrates the resynchronization of the network of Figure 3 when the master node has failed.

20 Figure 5 illustrates the resynchronization of the network of Figure 3 when a connection between two nodes has failed,

 Figure 6 is a flow chart illustrating the general principle of the method according to the invention,

25 Figure 7 shows means provided in each individual node for realizing the method according to the invention,

30 Figure 8 is a flow chart illustrating the most preferred embodiment of the method according to the invention, and

 Figure 9 is a flow chart illustrating another preferred embodiment of the method according to the invention.

35 Figure 2 illustrates a system employing the aforementioned self-organizing master-slave

synchronization (SOMS), which is a message-based synchronization method known per se. In this specific case, the system comprises five nodes (or devices) which are indicated by the reference numerals 1...5 according to their level of hierarchy. (Each number forms the SOMS address of the node, and the master node of the network has the smallest SOMS address.) The nodes interchange messages containing such SOMS addresses. In this way the nodes are able to identify each other by means of the address numbers and establish a synchronization hierarchy so that the whole network can synchronize itself with the master node.

As mentioned above, messages transmitted continually in the network are dependent on the applied message-based synchronization method. In addition, the messages are specific for each transmitting node. In the SOMS network a synchronization message contains three different parts: a frame structure, signature and check sum. The SOMS signature is the most important part of the SOMS message. It comprises three consecutive numbers D1 to D3:

D1 is the origin of the synchronization frequency of a node transmitting a SOMS message, i.e. the SOMS address of a node appearing as a master node to the transmitting node.

D2 is a parameter describing the quality of a connection, and it is typically a distance to a node indicated by D1. The distance is given as the number of intermediate nodes.

D3 is the SOMS address of a transmitting node.

The parameter most central to the present invention is possibly D3, since by means of this parameter it is possible to detect which interfaces are connected to the same neighbouring node.

Each node (or device) compares continuously incoming SOMS signatures with each other and selects the smallest amongst them. In the signature the different parts D1, D2 and D3 are combined into a single number by placing them in succession (D1D2D3) (for the sake of clarity, a dash will be inserted between the different parts in the text below as follows: D1-D2-D3). Accordingly, a primary criterion for the selection of the smallest address is the SOMS address (D1) of a node appearing as the master node to the preceding nodes, i.e. the node tends to be synchronized with a signal having a frequency originally derived from a node with the smallest possible address. In a stable situation, the whole network is thus synchronized with the same master node (as the master node of the whole network has the smallest SOMS address).

If two or more of the incoming signals are synchronized with the same master code, the one arriving over the shortest path (D2) is selected. The last criterion for selection is the SOMS address (D3) of the node transmitting the SOMS message, which is used for the selection if the incoming signals cannot be distinguished from each other in any other way.

After the node has accepted one of the neighbouring nodes as its new synchronization source on the basis of an incoming SOMS signature, it has to regenerate its own (outgoing) SOMS signature. The new SOMS signature can be derived from the selected smallest SOMS signature as follows: the first part (D1) is left intact; the second part (D2) is incremented by one, and the third part (D3) is replaced with the node's own SOMS address.

Each node also has its own internal SOMS signature X-O-X, where X is the SOMS address of the node. If none of the incoming SOMS messages contains a

signature smaller than the internal signature, the node uses its own internal oscillator or possibly a separate synchronization input as the source of its clock frequency. Of course, the outgoing SOMS message thereby employs the internal SOMS signature.

The nodes transmit continuously SOMS messages in all directions in order that any changed data in the SOMS signatures would be distributed as rapidly as possible and that they would know the current operating condition of neighbouring nodes. The SOMS signatures cannot be compared with each other until the incoming SOMS messages have been accepted and the SOMS signatures have been extracted from the messages.

When the first SOMS message is received from a specific transmission line, the SOMS signature contained therein is accepted immediately for comparison if the message is faultless. When the incoming transmission line has an accepted SOMS signature and faultless messages containing the same signature are received continuously, the situation remains unchanged. If the SOMS message is found to be faulty, the current SOMS signature is retained until (for example) three successive faulty SOMS messages have been received. At this stage the old SOMS signature is no longer accepted for comparison. Waiting for three successive SOMS messages aims at eliminating temporary disturbances.

If no SOMS message is received from the line and there is no line failure, the current SOMS signature is rejected only after a period of time corresponding to (for example) three successive SOMS messages. If the line fails totally, the SOMS signature is rejected immediately. If no appropriate SOMS signature is available for comparison due to disturbances in the incoming signal, the SOMS signature of the transmission line is rejected. A constant-value signature where all

parts (D1, D2, D3) have their maximum value (MAX-MAX-MAX) is thereby used in the comparison as the SOMS signature of this incoming transmission line.

5 When a new changed SOMS signature is detected in an incoming SOMS message, it is accepted immediately for comparison, if the message is faultless. In this way there will be no unnecessary delays in network changes.

10 Initially each node employs its own internal synchronization source, and transmits its own internal SOMS signature X-O-X to the other nodes. This signature is also compared with incoming SOMS signatures. If none of the incoming signatures is smaller than the internal signature, the node continues to use its own internal timing.

15 In Figure 2, the SOMS network is shown in an initial state when none of the nodes (or devices) has yet processed any one of the incoming SOMS messages. In all nodes, the highest priority is assigned to the internal SOMS signature of the node as no other signatures have yet been processed. In Figure 2, the SOMS signatures are indicated beside each node to which they are transmitted, and the selected signature is framed (in the initial situation shown in Figure 2 all nodes employ their internal timing source). Lines used
20 in synchronization are drawn by a continuous line and standby lines are drawn by a broken line (in the initial situation shown in Figure 2, all lines are standby lines).

25 When the nodes start to process the incoming SOMS messages, node 1 retains the use of the internal timing, nodes 2 and 4 synchronize themselves with node 1 on the basis of the signature 1-0-1, node 3 is synchronized with node 2 (2-0-2), and node 5 with node 3 (3-0-3). At the same time the nodes generate their own
30 new SOMS signatures as described above and provide their
35

outgoing SOMS message with the new signature. The network in a stable situation is shown in Figure 3. All nodes have synchronized with the master node 1 over the shortest possible path.

5 If the smallest one of the SOMS signatures entering the node changes or is lost totally when the connection fails, the node selects a new synchronization direction on the basis of the second smallest SOMS signature. Prior to this, however, the node is forced
10 to change over to internal timing, which it retains for a preset time period in order for any faulty SOMS signatures occurring in the network to be eliminated. For instance, if node 1 in the situation of Figure 3
15 should fail, nodes 2 and 4 would no longer receive the signature 1-0-1, with which they were synchronized. They now accepted immediately the second smallest SOMS signature, the network would no longer be synchronized with a single master node but a synchronization loop would result. When node 1 fails, node 2 still receives
20 the signatures 1-1-4 and 1-2-3, and node 4 receives the signatures 1-1-2 and 1-2-5, as nodes 3 and 5 have not yet responded to the changed situation. If the second smallest signatures were accepted immediately, node 2 would be synchronized with node 4, and node 4 with node
25 2. This situation is prevented by the above-mentioned forced state of internal timing, in which the nodes start to use their own internal timing source and transmit their own internal SOMS signature (X-O-X). Nodes which were synchronized with the node now in the
30 state of internal timing detect that a change has occurred in the network and that the SOMS message on which the former synchronization was based is no longer valid as it has been changed into the internal SOMS message of the neighbouring node. As a consequence, the

nodes also enter into the forced state of internal timing for a preset time period.

5 If the master node fails in the case of Figure 3, the nodes 2 and 4 are immediately forced to enter into the state of internal timing when they lose the incoming SOMS signature 1-0-1. When the nodes 3 and 5 detect the change that has taken place in the nodes 2 and 4, they are also forced to enter into the state of internal timing. When node 2 reverts to the normal state, it receives the internal SOMS signatures (3-0-3 and 4-0-4) from the nodes 3 and 4 and retains the use of the internal timing as the SOMS signatures received from outside are not smaller than its own internal signature (2-0-2). Node 4 is then synchronized with node 10 2. After having stabilized, the network is in the state shown in Figure 4, where node 2 is the new master node of the network. If for example only the connection between the nodes 1 and 2 breaks (Figure 5), only node 2 is forced into the state of internal timing. On 20 reverting to the normal state it synchronizes itself with node 4 having a connection to the master node of the network. After the stabilization of the entire network, the synchronization still originates from node 1 despite the break. This is illustrated in Figure 5.

25 If there are several transmission lines, used for synchronization, between two nodes in the above-described network employing message-based synchronization, and if one of these lines to the neighbouring node is selected as the primary source of 30 synchronization, a change in the signature transmitted by the neighbouring node may cause alterations in the node synchronization. It is then possible, as described above, that the correct outcome is achieved only through several intermediate states.

In order that correct decisions concerning synchronization could be made rapidly also in such change situations, the method according to the invention follows the general principle illustrated in Figure 6. Whenever the node control unit has received (step 61) a changed signature from one of the interface units of the node (one interface unit may comprise one or several interfaces), it examines whether another interface is possibly connected to the same (neighbouring) node (step 62). If it is, the signature is copied to also apply to all the other interfaces connected to the same (neighbouring) node (step 63). The node checks only after this the possible changes in synchronization (changes the priority list, if required, and forms a possibly required new outgoing signature) and continues its normal operation (step 64). If it is detected in step 62 that no other interfaces are connected to the same (neighbouring) node, the node enters directly into step 64.

The idea of the invention is thus to copy the first changed signature to immediately apply also to the other interfaces connected to the same node (if the signals of these interfaces are used for synchronization).

It should also be noted that in Figure 6 step 61 only concerns the signature, even though the inventive idea primarily relates to the changed signature. However, it is possible in principle that the node control unit asks each interface for its incoming signature, which is then processed as if the interface had transmitted itself its own signature during a change situation, i.e. the signature from the interface is copied to also apply to the other interfaces connected to the same neighbouring node and used for synchronization. Therefore this possibility should not

be excluded either. However, the examples below relate to a situation where the process is started by a change in the signature.

Figure 7 shows means provided in each node for realizing the method according to the invention. The general structure of the node comprises several parallel interface units IU1, IU2...IUN each of which is connected to a neighbouring node, and a control unit CU which is shared by all interface units and which is the location of decision-making concerning the synchronization. The figure shows two transmission connections A and B between a system node and neighbouring nodes, both connections being connected to their own interface unit. One interface unit may also comprise several interfaces one or several of which may be connected to the same node. The transmission connections are typically for example PCM lines of 2 Mbit/s complying with the CCITT (currently ITU-T) recommendations G.703 and G.704, or SDH lines according to the recommendations G.708 and G.709. Synchronization messages can be transmitted in different ways in such signals; one example is disclosed in the co-pending Finnish Patent Application 940926 which also describes the general structural models of the node.

Each transmission connection is connected to a signal transmission and reception means 13a and 13b, respectively, which process the physical signal. The means 13a and 13 b forward the synchronization message to an associated synchronization message transmission and reception means 16a and 16b, respectively. The transmission and reception means 16a and 16b for example check whether the message is faultless and forward the message to a centralized node synchronization decision means 23 having a respective input connected to the output of the respective transmission and reception

means 16a, 16b. The signal transmission and reception means 13a and 13b also supervise the quality of the received signal and store information thereon into interface-specific fault databases 24a and 24b, respectively. The synchronization message transmission and reception means 16a obtains fault data from the database 24a and the transmission and reception means 16b from the fault database 24b, respectively. The signal transmission and reception means monitor failures/changes in the connection in a manner known per se.

The decision means 23 of the control unit CU compares the messages and stores them in a memory 21, e.g. in priority order so that the selected synchronization signature always has the highest status. The decision means also receives the fault data of a signal from the corresponding interface unit in the form of a synchronization message (the signature then being in the form MAX-MAX-MAX) or as separate fault data. When the decision means judges from the supplied data that the node has to enter into the standard state for the preset time period, it selects the source of its timing as defined in the applied synchronization method for this kind of situation; it applies an appropriate synchronization signature to the interface-specific synchronization message transmission and reception means 16a and 16b from a memory 22 (where it generates an outgoing signature used in each particular case), and starts a timer means 25. The node informs the neighbouring nodes about the change that has occurred by transmitting the new signature. When the timer means 25 indicates that the preset time period K has expired, the decision means 23 is again allowed to select the source of timing according to a normal procedure.

The node decision means 23 has in its memory information of the synchronization signatures from all interfaces. The decision means forms of these signatures a ready priority list in which each node interface (interface number) is in the place determined by its incoming signature in such a way that the top of the list is occupied by the interface corresponding to the selected signature, the next one is the interface receiving the signature on the second highest level, etc. By means of this priority list, the decision means can form for the node a separate synchronization list comprising the top of the priority list, for example the first three interfaces. The decision means stores also this synchronization list in the memory. The following table shows one example of forming a priority list and a synchronization list on the basis of signatures entering a node.

Incoming signatures		Priority list		Synchronization list	
Inter-face	Signature	Level	Inter-face	Level	Inter-face
1	2-4-7	I	6	I	6
2	2-4-9	II	3	II	3
3	2-3-10	III	1	III	INT
4	2-4-14	IV	2		
5	2-4-11	V	5		
6	2-3-10	VI	4		
INT	20-0-20	VII	INT		

The basic data for forming a synchronization list consists of the incoming signatures and the SOMS address (20) of the node. The incoming signatures also include an interface INT which corresponds to the node-
5 internal oscillator, the frequency of which can be used (in failure situations) as the timing source. The internal signature is formed as described above on the basis of the node's own SOMS address. The timing source could also be provided by a direct external
10 synchronization input which would receive the signature determined by the user when the incoming clock signal would be in order.

A priority list is formed as described above by placing all timing sources in an order of quality on
15 the basis of their signatures. The first two interfaces (6 and 3) have been selected from this list onto the three-level synchronization list, the interfaces being connected to the same neighbouring node (node no. 10). The third level of the synchronization list is occupied
20 in this exemplary case by the internal timing.

If the synchronization signature arriving at the selected interface 6 changes, the changed signature is immediately copied, according to the invention, also for interface 3 on the lists above.

Figure 8 shows the realization of the copying procedure in the decision means 23. Whenever the node control unit has received (step 81) a changed signature from one of the node interfaces, the decision means selects the first interface from among the interfaces
25 on the priority list (step 82) and examines whether it is connected to the same neighbouring node as the interface which received the changed signature (step 83).
30

In the SOMS network this examination may be
35 conducted for example by utilizing the third part D3 of

the synchronization signature, the part indicating the SOMS address of the node transmitting the signature. (Two nodes must not have the same SOMS address in the network.) When other message-based synchronization method are used, the aforementioned information must be added to the synchronization messages to be transmitted if this information is not otherwise used in the method.

5

As an alternative to the use of the SOMS address, the user may define which interfaces are connected to the same neighbouring node.

10

If the decision means detects that the selected interface is connected to the same neighbouring node as the interface which received the signature, it copies the new signature also for the selected interface (step 84a).

15

It is then examined whether the selected interface was the last interface on the priority list (step 85). This stage is entered into directly after step 83, if the examination in that step resulted in a negative result. If the interface is the last one, the changes possibly caused in the synchronization by the new situation are checked, and the operation is continued normally (step 85b). If the interface is not the last one, the decision means selects the next interface (step 85a) and then continues the procedure again from step 83. In practice the interfaces may also be examined for example in numerical order (instead of the order of priority).

20

25

It is possible to add to this most preferred embodiment an additional checking step 83a between steps 83 and 84a as shown in Figure 9, this step comprising the examination of whether the (old) signature of the selected interface is the same as the old signature of the interface which received the new signature. If it is, copying is performed, but otherwise step 85 is

30

35

entered into. The purpose of this additional step is for example to avoid unnecessary writing (writing of the signature over a signature having the same value). This is important especially in cases where the operating life of the memory used is measured in numbers of writing operations. In addition to unnecessary writing, it is also possible to avoid the checking of the changes on the priority list. (When a signature is written for an interface, it is examined whether it causes any changes on the priority list. If it is detected in the additional checking step that copying is not necessary, the checking of the priority list can also be avoided). The additional step 83a also provides further backup for step 83.

It is also possible to check before the copying whether the signal of the selected interface is in order. The new signature is then copied for the signature corresponding to the interface only if its signal is in order. This checking must be performed, if the faults of the signal are encoded in its signature (in a failure situation the signature has for example the form of MAX-MAX-MAX). If the faulty status is stored separately in its own fault database, the signature can be copied also for the faulty interfaces, if desired, since they will not be used as the source of synchronization on the basis of the fault database.

According to another embodiment of the invention, copying can also be utilized when a node of an external system is connected to a message-based system by means of at least two transmission lines. If the synchronization status of the node of the external system can be transmitted to the message-based system, copying can also be used similarly for interfaces connected to the node of the external system, if in the synchronization method employed by the external system

the node transmits the same signature to all directions, or if the same message, as far as synchronization is concerned, is transmitted at least over several connections between two nodes. Finnish Patent
5 Application 940927 describes in greater detail the connection of an external system to a message-based system in such a way that the synchronization status of the external system can be transmitted to the message-based system.

10 If the node uses an external synchronization source, it is possibly necessary, depending on the situation, to first (before steps 61 and 81 in Figures 6 and 8, respectively) examine whether the signature originated in a normal interface, a separate
15 synchronization input, or some other separate external source. If the signature arrives from a normal interface, it may be a synchronization signature transmitted by a neighbouring node. It might be necessary to examine then whether the signature is a
20 signature from a neighbouring node or possibly a standard signature (if the node utilizes them) which the signal has been provided with at the interface. The above-described steps are only started after these examinations, when it is sure that the signature has
25 arrived from a neighbouring node.

Even though the invention is described above with reference to the examples according to the accompanying drawings, it is clear that the invention is not restricted thereto, but it may be modified within
30 the inventive idea disclosed above and in the appended claims. Even though the SOMS system has been used as an example above, the solution according to the invention is applicable in all message-based systems where the node transmits the same synchronization signature to all
35 directions, or the same signature is transmitted over

each connection between two nodes, or the system otherwise knows the interfaces between two nodes over which the same synchronization signature is transmitted. The priority and/or synchronization list should also be understood as a list or table generally describing the incoming signatures and the corresponding interfaces.

Claims:

1. A hierarchical synchronization method for
5 a telecommunications system employing message-based
synchronization and comprising a plurality of nodes
interconnected by transmission lines (A, B), wherein the
nodes interchange signals containing synchronization
10 messages with a synchronization signature indicating the
priority of the corresponding signal in the internal
synchronization hierarchy of the system, whereupon there
are several transmission lines between two nodes and the
same synchronization signature is transmitted over more
15 than one of these transmission lines,
c h a r a c t e r i z e d in that when the
synchronization signature from a neighbouring node
connected to several node interfaces changes, the node
copies the new signature of the interface which first
20 received the changed signature to immediately apply also
to the other interfaces connected to the same
neighbouring node and used for synchronization.

2. A method according to claim 1,
c h a r a c t e r i z e d in that only a deterioration
of a synchronization signature is considered as a change
25 in said signature.

3. A method according to claim 1,
c h a r a c t e r i z e d in that before the changed
signature is copied for the signature corresponding to
the interface, it is examined whether the signal
30 received by the interface is appropriate for
synchronization, and copying is only performed for
interfaces having signals which are found to be
appropriate.

4. A method according to claim 1,
35 c h a r a c t e r i z e d in that before the changed

signature is copied for the signature corresponding to the interface, it is examined whether the signature previously received by the interface is the same as the old signature of the interface which received the changed signature, and copying is performed only if the examination has a positive result.

5
10
15
20
25
30
35

5. A hierarchical synchronization method for a telecommunications system employing message-based synchronization and comprising a plurality of nodes interconnected by transmission lines (A, B), wherein the nodes interchange signals containing synchronization messages with a synchronization signature indicating the priority of the corresponding signal in the internal synchronization hierarchy of the system, whereupon there are several transmission lines between two nodes and the same synchronization signature is transmitted over more than one of these transmission lines, characterized in that the node automatically receives from its interfaces an indication of the synchronization signatures they have received, whereupon the node copies the signature received from the interface to immediately apply also to the other interfaces connected to the same neighbouring node and used for synchronization.

25
30
35

6. A method according to claim 5, characterized in that of the interfaces connected to the same neighbouring node only the signature of the interface providing the first signature is copied.

30
35

7. A node equipment for a telecommunications system employing message-based synchronization and comprising a plurality of nodes interconnected by transmission lines (A, B), said node comprising

- several interfaces to which the transmission lines (A, B) to the neighbouring nodes are connected,

5 - means (13a, 13b, 16a, 16b) for forming a synchronization signature to be transmitted between the nodes from a signal received at an interface, said synchronization signature indicating the priority of the corresponding signal in the internal synchronization hierarchy of the system,

10 - means (23) for comparing the synchronization signatures received from interfaces with each other in order to select the signature with the highest priority as the source of the node synchronization, and

15 - means (23, 16a, 16b) for forming the node outgoing synchronization signature on the basis of the selected synchronization signature, characterized in that said comparing means (23) also comprise copying means for copying the synchronization signature of an interface to relate to the interfaces connected to the same neighbouring node before the comparing means perform the comparison and selection.

20 8. A node equipment according to claim 7, characterized in that said copying means are responsive to the change in the synchronization signature received at the interface.

1/6

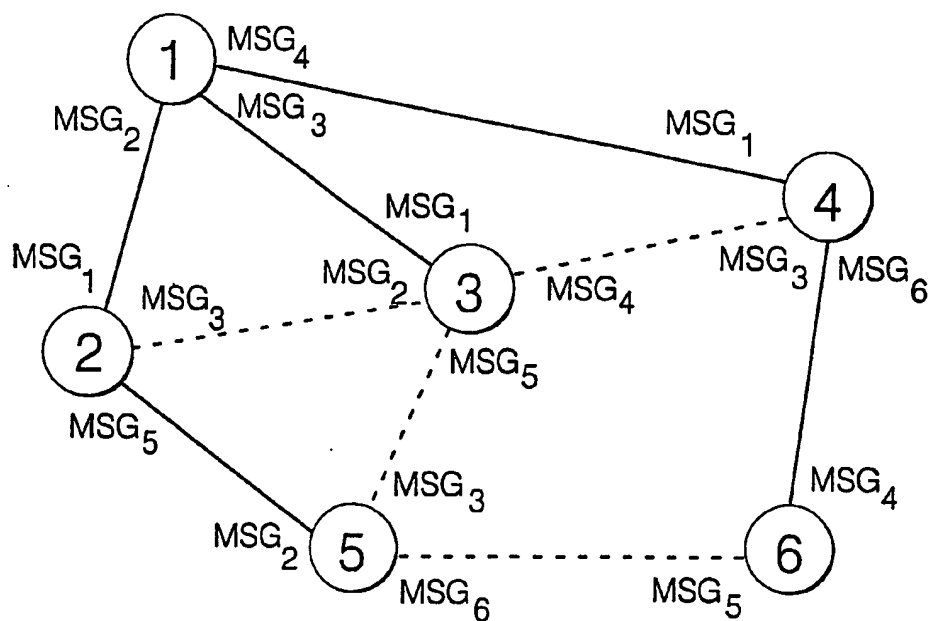


FIG. 1

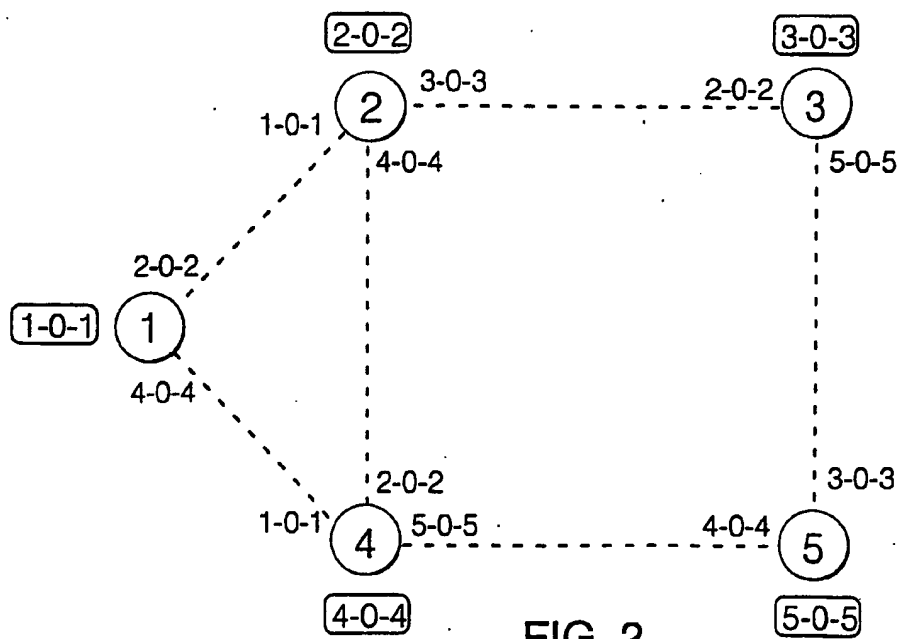


FIG. 2

2/6

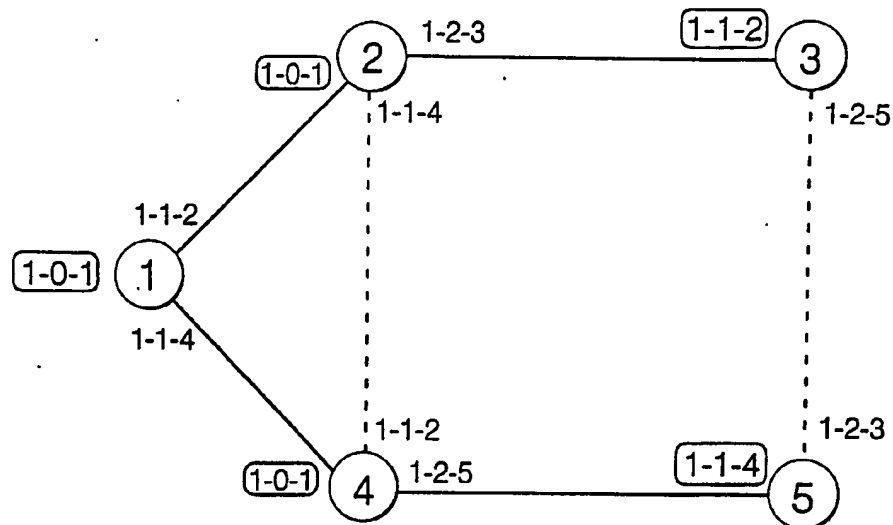


FIG. 3

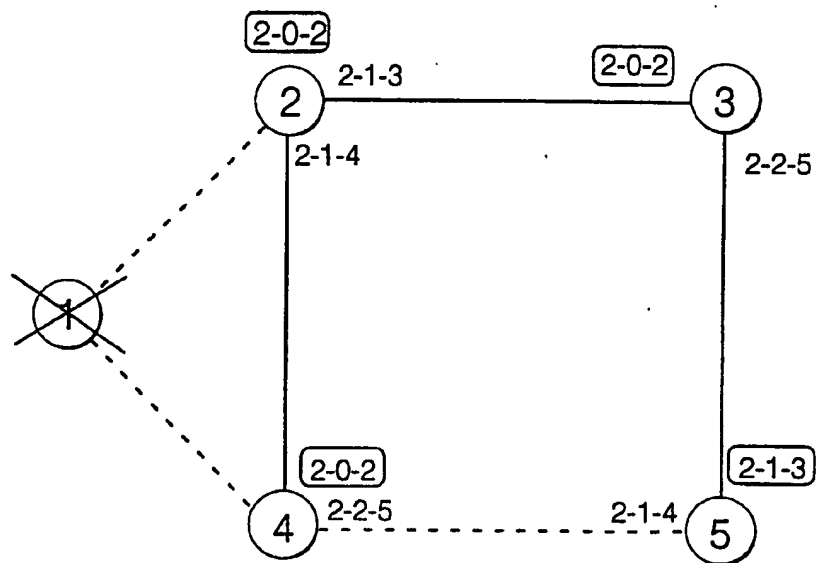


FIG. 4

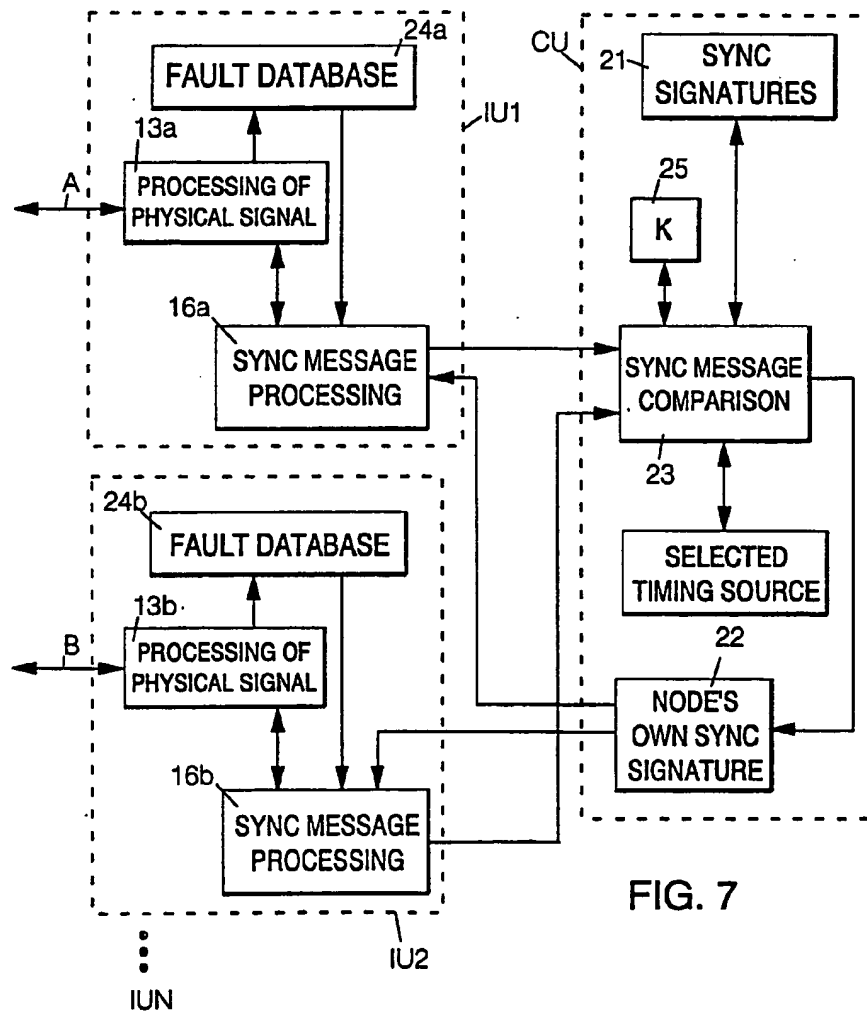
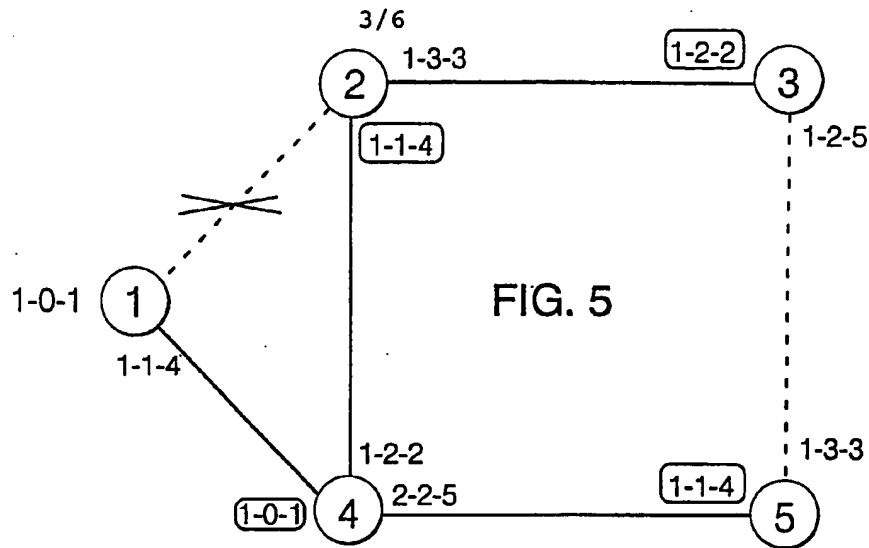


FIG. 6

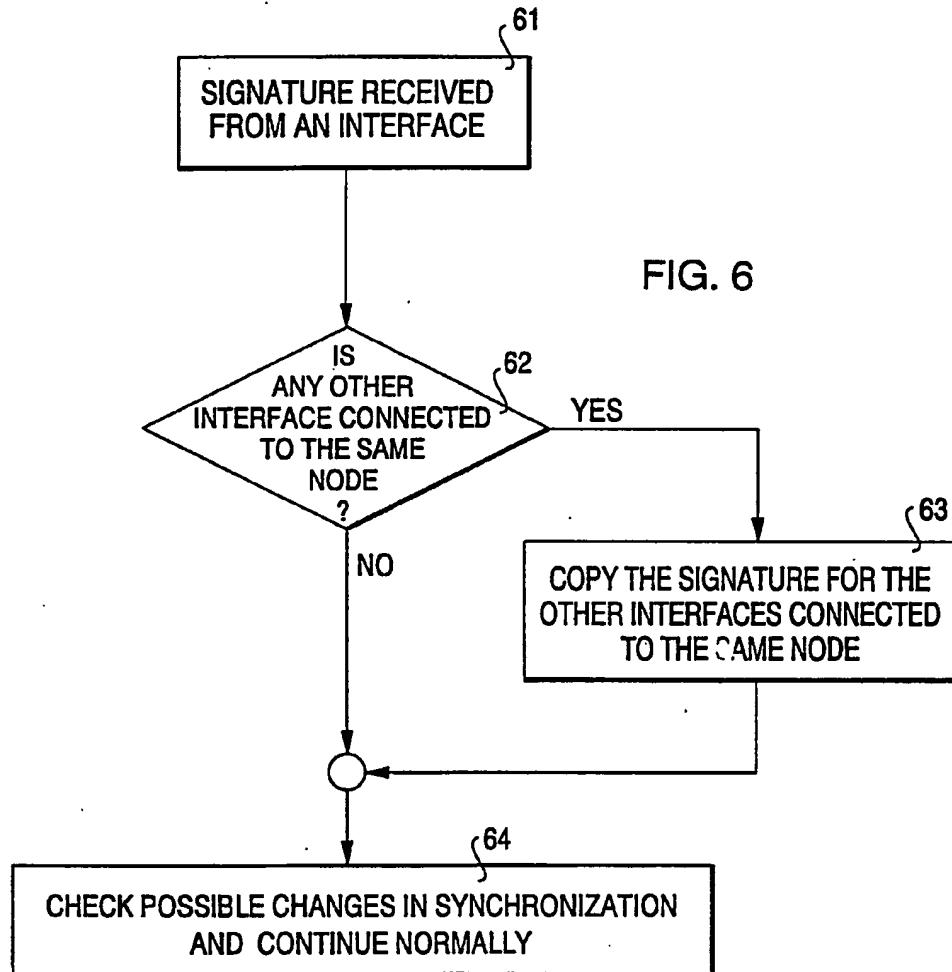


FIG. 8

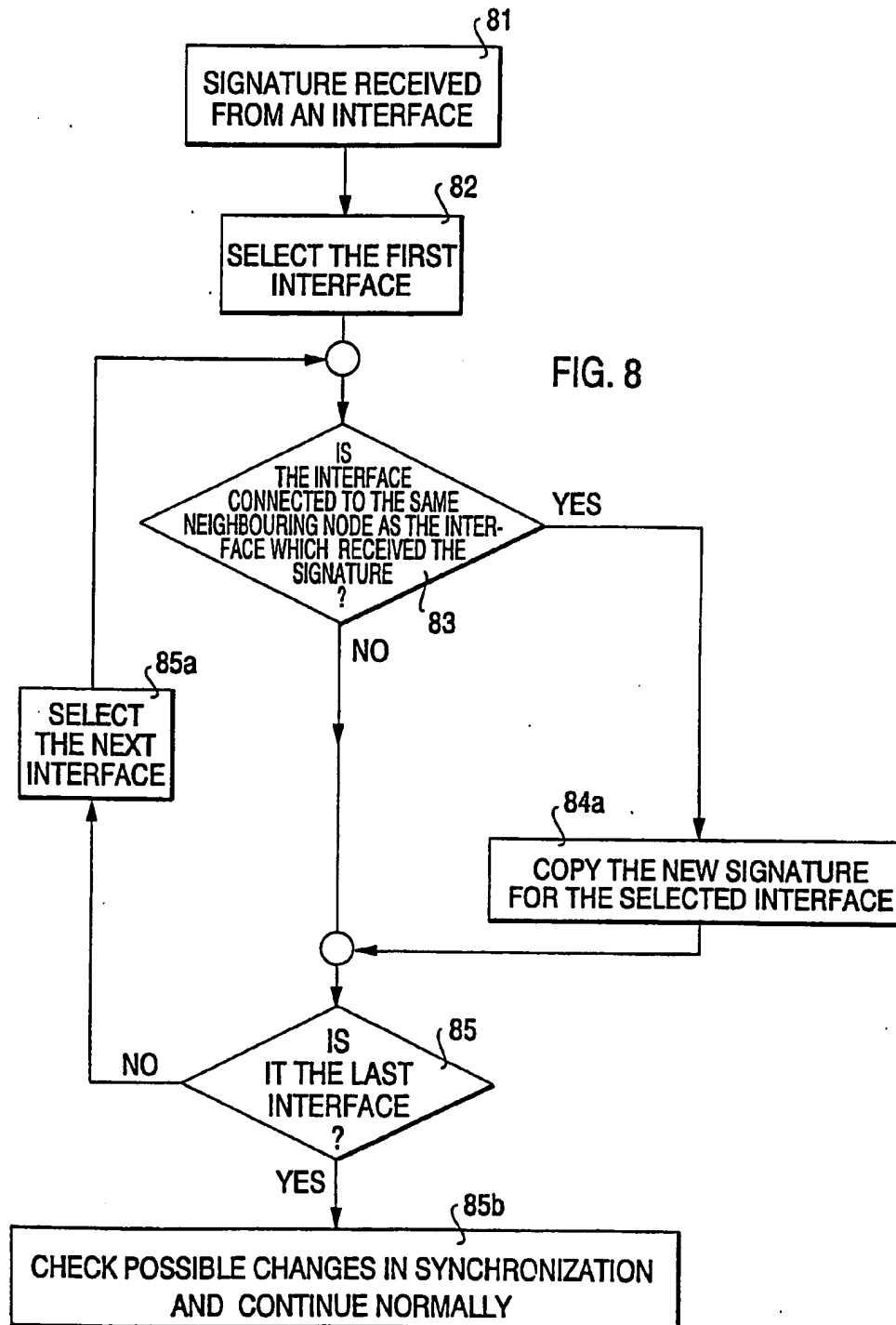
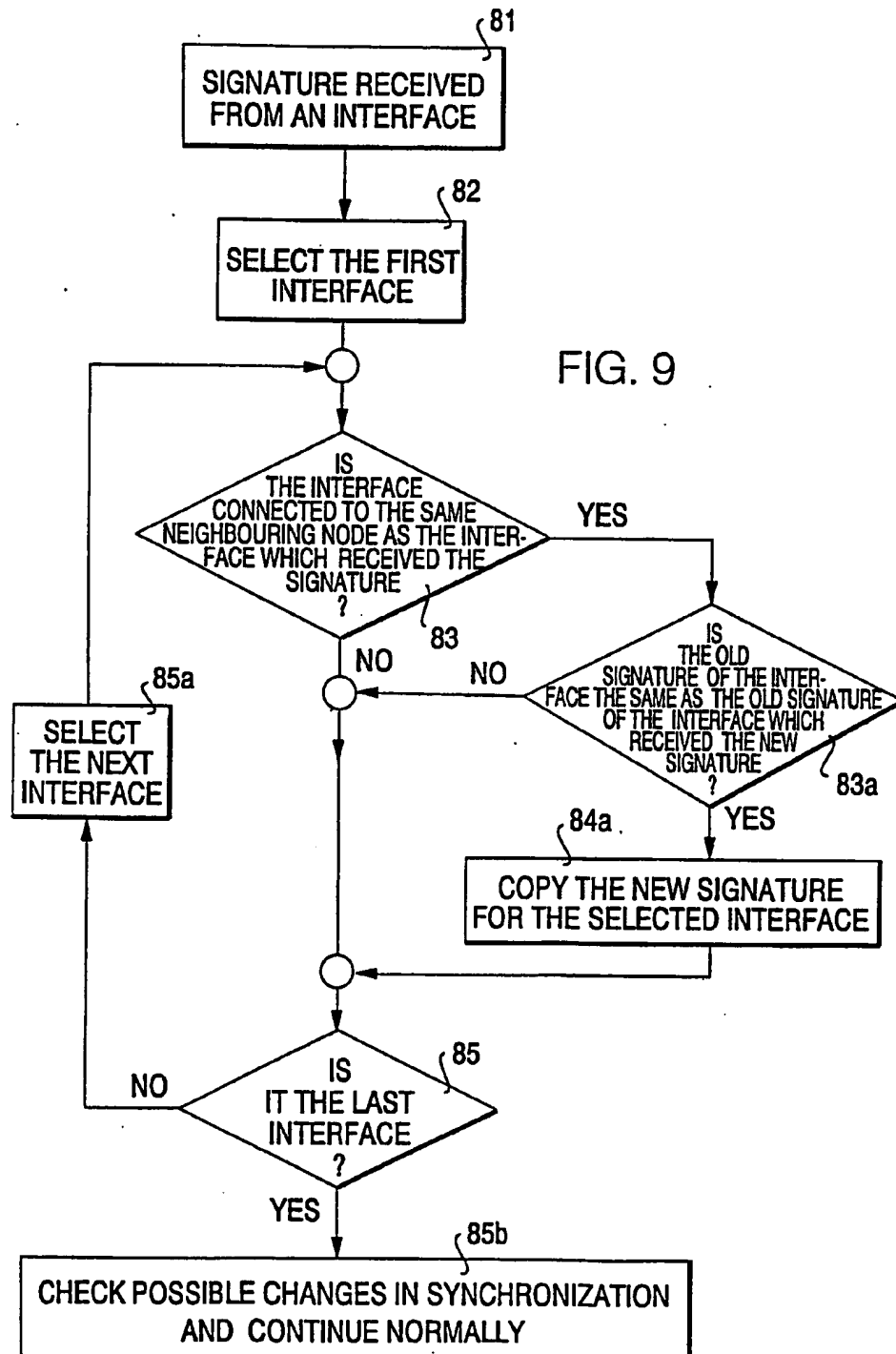


FIG. 9



PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



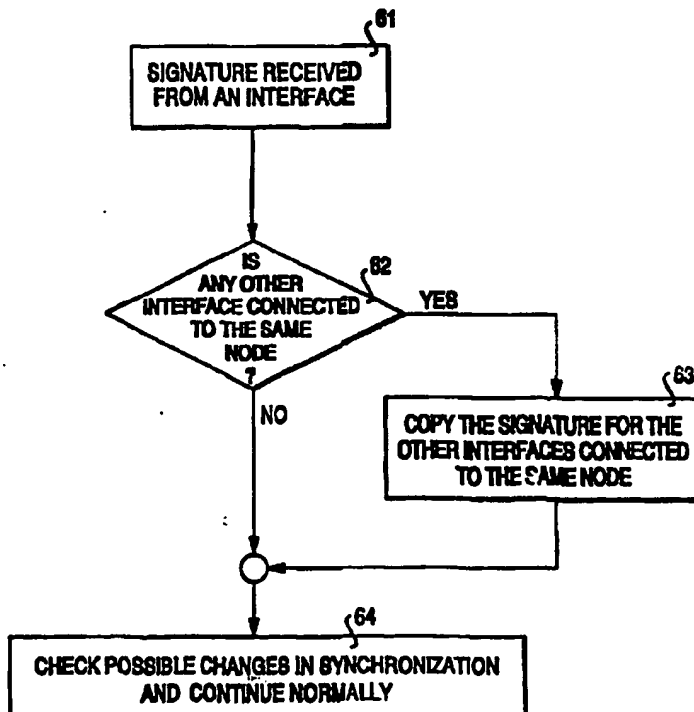
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04J 3/06		(11) International Publication Number: WO 95/24801
A3		(43) International Publication Date: 14 September 1995 (14.09.95)
(21) International Application Number: PCT/FI95/00113		(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).
(22) International Filing Date: 28 February 1995 (28.02.95)		
(30) Priority Data: 940980 1 March 1994 (01.03.94) FI		
(71) Applicant (for all designated States except US): NOKIA TELECOMMUNICATIONS OY [FI/FI]; Mäkkylän puistotie 1, FIN-02600 Espoo (FI).		
(72) Inventor; and (75) Inventor/Applicant (for US only): KAINULAINEN, Jukka [FI/FI]; Ratavallintie 26 H 60, FIN-00720 Helsinki (FI).		
(74) Agent: OY KOLSTER AB; Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).		
Published <i>In English translation (filed in Finnish). With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>		
(88) Date of publication of the international search report: 5 October 1995 (05.10.95)		

(54) Title: **HIERARCHICAL SYNCHRONIZATION METHOD**

(57) Abstract

The invention relates to a hierarchical synchronization method for a telecommunications system employing message-based synchronization and comprising a plurality of nodes interconnected by transmission lines (A, B). In the method the nodes interchange signals comprising synchronization messages with a synchronization signature indicating the priority of the corresponding signal in the internal synchronization hierarchy of the system. There are several transmission lines between two nodes, and the same synchronization signature is transmitted over more than one of these transmission lines. In order to enable as fast resynchronization as possible, the node operates in such a way that when the synchronization signature received from a neighbouring node connected to several node interfaces changes, the node copies the new signature of the interface which received the changed signature to immediately apply also to the other interfaces connected to the same neighbouring node and used for synchronization.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CC	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LJ	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TC	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 95/00113

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04J 3/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04J, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2986723 A (G.P. DARWIN ET AL), 30 May 1961 (30.05.61) --	1-8
A	IBM Technical Disclosure Bulletin, Volume 25, No 11B, April 1983, L.S. Rogers, "CLOCK SOURCE SELECTION METHOD IN DISTRIBUTED COMMUNICATION SYSTEM NETWORKS" page 6293 - page 6298 --	1-8
A	US 4837850 A (MANFRED MAISEL ET AL), 6 June 1989 (06.06.89) --	1-8
A	EP 0435395 A2 (PHILIPS PATENTVERWALTUNG GMBH), 3 July 1991 (03.07.91) --	1-8

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

- * Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "B" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

4 Sept 1995

04-09-1995

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer
Per Lindberg
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 95/00113

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 9411965 A1 (NOKIA TELECOMMUNICATIONS OY), 26 May 1994 (26.05.94) --- -----	1-8

INTERNATIONAL SEARCH REPORT

Information on patent family members

31/07/95

International application No.

PCT/FI 95/00113

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 2986723	30/05/61	DE-B- 1180404 FR-A- 1284176 GB-A- 965670	00/00/00 00/00/00 00/00/00
US-A- 4837850	06/06/89	AT-T- 117478 DE-A- 3629931 DE-D- 3751000 EP-A, A, A 0262705	15/02/95 10/03/88 00/00/00 06/04/88
EP-A2- 0435395	03/07/91	DE-A- 3943052	04/07/91
WO-A1- 9411965	26/05/94	NONE	